Automatic 3D Routing for Aircraft Wire Harness Design

Introduction

Aircraft wire harness systems are becoming increasingly complex. Their design and manufacturing is a challenging business. The Airbus A380 accommodates 530km of cables, 100,000 wires and 40,300 connectors, which need to be routed and installed inside a complex environment, competing in terms of space reservation with cargo, passenger and equipment.

The complexity of wire harness design is amplified by the fact that:
1. the wire harness design process is multidisciplinary;
2. the continuous innovation in aircraft systems raises new problems;
3. the number of requirements to be fulfilled is large and steadily growing;
4. wire harness design is a very labor intensive process.

Objective

Wire harness design consists of two parts, Electrical Design and Physical Design.

Why: This research focuses on the physical design part, namely Harness 3D Routing, i.e., How to route the harness in aircraft.

How: The objective of this research is to automate the 3D routing process via a software design system which is able to:
1. Generate wire harness Digital Mockup (DMU) automatically;
2. Update wire harness DMU automatically;
3. Shorten product lead time;
4. Decrease the design errors

Methods

1. Optimization

Wire harness design could be handled as an optimization problem, with the objective of minimizing the cost of the harness, while satisfying a set of design constraints.

\[
\min f(x)
\]

\[
f(x) = \sum_{i} L_{i}(x)C_{0}(x)
\]

with respect to \(x\);

subject to \(C_{j}(x) \leq 0\)

2. Two steps path finding strategy

Optimization is a suitable method to enable wire harness routing automation, as far as the number of design variables and their initial value can be identified, in this case the number and position of the wire harness break – out points and clamps. To this purpose, a two-steps design method is adopted. The first step is called Initialization, which is responsible for identifying the design variable set and generating a preliminary harness configuration via a map road based path finding method. The second step is called Optimization, which refines the preliminary configuration using classical optimization methods.

3. Knowledge Based Engineering: Both the Initialization and Optimization processes need product and process knowledge to achieve design automation. In addition, the geometry model is one of the required outputs. These features make KBE the most suitable technology. KBE allows the automation of all the knowledge intensive but repetitive steps in the design process, by means of dedicated software applications that can store and re-use product and process knowledge, including complex geometry manipulations.

A design framework based on KBE has been developed to support 3D harness routing, which is called Design and Engineering Engine (DEE)

Result

The development of a Design and Engineering Engine demonstrator system for automatic 3D routing of aircraft wire harnesses has been completed. The Initiator is able to read in harness logical definition as well as other inputs and to generate accordingly a preliminary definition of the wire harness for following optimization. The Optimization is able to modify the design variables set produced by the Initiator, and produce an improved solution of minimum cost and fully compliant to the given set of design constraints.

Future Development

Validation and verification of the automatic 3D routing system by means of harness and airframe models of realistic complexity

Publications
